Monodzukuri in the New Era in Intellectual Property Creating Companies in Japan

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This paper aims to argue a new style “Monodzukuri” involved in the context of knowledge and intellectual properties creation and exploitation in this new era. The Japanese word “Monodzukuri” is very difficult to translate into English. In addition, the present meaning of Monodzukuri is no more the same as it used to be, In this paper, I observe Japanese semiconductor companies, and I define Monodzukuri as creating vehicles that deliver “Chi” to customers, whereas “Chi” is composed of knowledge, wisdom and mind (Takanashi, T. [2006]). In this paper, I suggest a new style Monodzukuri through my observation and also the new style Monodzukuri spirit be innovative mind supported by science based technology together with sophisticated skills, concept oriented attitude and a sophisticated intellectuals property policy.

KeyWord：intellectual property creating companies, new-style Monodzukuri, shared vision in projects, open mind in Monodzukuri, continuity and discontinuity of tradition

1. The New Style “Monodzukuri”

This paper aims to argue a new style “Monodzukuri” involved in the context of knowledge and intellectual properties creation and exploitation in this new era. The Japanese word “Monodzukuri” is very difficult to translate into English. In addition, the present meaning of Monodzukuri is no more the same as it used to be, as I will explain afterwards. In this paper, I observe Japanese semiconductor companies, and I define Monodzukuri (see METI [2005])[1] as creating vehiclesthat deliver “Chi” to customers, whereas “Chi” is composed of knowledge, wisdom and mind (Takanashi, T. [2006])[2]. In this paper, I suggest a new style Monodzukuri through my observation and also the new style Monodzukuri spirit be innovative mind supported by science based technology together with sophisticated skills, concept oriented attitude[3] and a sophisticated intellectual property policy.

The outline of the paper is as follows : Firstly, I will review previous studies and imply new style Monodzukuri in the 21st century. Secondly, the topic will be concept creation and the Agile line concept is discussed Thirdly, I discuss the relationship among science, technology, technical skills and shared value embedded mind. Then I will suggest some implications.

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2. Previous Studies

Firstly, I want to talk about ambiguity in the context of innovation and Monodukiuri.

In ancient Japan, Monodzukuri used to mean sward making, pottery and lacquer ware and ink brush for calligraphy in Japanese language. Potteries were began to be created in the late 700s. It was discovered that lacquer wares had begun to be created in more than 4000 years ago in this country. In these ancient period, Monodzukuri meant similar to craft and, remarkably, craftsmanship was highly respected in Japan.

According to recent studies on Japanese technology of 18th century, Japanese people used to have unique technology concerning, such as ceramics and robots that moves with gears. It seemed that the innovative and inventive spirit of Monodzukuri bridges between unique technological knowledge and products. However, it seems that Japanese people lost their innovative and inventive Monodzukuri spirit and mind owing to rapid changes of the economy.

Monodzukuri seemed to come to mean only manufacturing in Japanese language, where Japanese business enjoyed a competitive advantage of mass production in the world market in the 1980s. In 1990s, the macroeconomic situation changed dramatically partly for the global mega-competition, where lots of Asian and former Eastern companies participated into the market. In addition, customers' needs varied extremely. Then the former advantage of Japanese companies turned into the present disadvantage. The technology level is still high, as a semiconductor industry that pursues 45nm level technology shows, however, the technological development does not lead to the GDP growth, as OECD technology outlook pointed out.

That's why the present author is interested in making up the new style Monodzukuri and come to the definition as creating vehicles that deliver "Chi" composed of knowledge, wisdom and mind to customers. Even if we have excellent knowledge and intellectual properties, we cannot give benefits to customers unless we deliver "Chi" to them through products and services produced through Monodzukuri together with Monodzukuri spirit.

One of problems is that, will we be better off if we remind and relearn the traditional Monodzukuri spirit we used to passed ? The present Japan is almost completely different from what it used to be.

Previous studies analyze Monodzukuri based on the architecture of production systems and design rule theory. Fujimoto, T. [2002] and [2003] insist the Monodzukuri capability in which traditional Japanese companies' strength exists on forming and shaping devices in integral and closed architecture, whereas Baldwin, C. Y. and K. B. Clerk [2000] have suggested a Modular system as a solution to a problem of increasing complexity in technological innovation in recent economic society. Baldwin, C. Y. and K. B. Clark [2000] does not necessarily mention about Monodzukuri, however, we had better review their work in order to understand Monodzukuri better. Modularization divides a production system into many sub-

systems (pieces of a modular set) and enables designers, manufacturers and users to get a higher degree of flexibility from their integral production system. In the modular system, there are two types of companies, one that designs the design rules for the architecture of a production system and companies that are in charge of individual modular sets. Companies that are in charge of individual modular sets are responsible only for individual modular units. A product that has a typical modular architecture is the computer.

On the other hand, Fujimoto, T. insisted on the competitive advantage of integral architecture of the Japanese Automobile industry. He analyzed Monodzukuri based on the two intersecting manufacturing system axes of architecture design rules of modular / integral and open / closed. According to Fujimoto, T. [2003], a product is composed of design architecture information and media. Here the word media uses the same meaning of vehicle or device. He says that Japanese companies are good at the integral system and closed process architecture and that is partly why Japanese automobile products that basically hold to this architecture have a competitive advantage, whereas US firms have a competitive advantage in the computer and semiconductor industry that hold to modular system and open process architecture.

Traditionally, we Japanese might call Monodzukuri as creating the integral and closed parts, though in the present economy, there are four variations to consider. We still tend to regard Monodzukuri as production based on the integral system and closed process architecture. Sometimes this attitude is very creative and effective and sometimes it changes to inhibit innovation.

We think that Monodzukuri in the new era no longer means only creating products that are based on integral and closed architecture. We had better incorporate modular part design. In addition, it is necessary for us to be aware of and give attention to the fusion of science, technology, and skills as the key factors in creating innovative products and services. Furthermore, creating a concept is an important part of Monodzukuri., where product content is tangible but creating concept, service and software contents are intangible (METI [2005]).

3. Concept Creation and Monodzukuri in HALCA Project

One of the major innovations of the 20th century was the semiconductor. The semiconductor itself is material that has intermediate characteristics between a conductor and an insulator. However, the word “semiconductor” is usually used for devices such as transistors and diodes, arranged on Integrated Circuits. In the 1980s, the semiconductor used for DRAM (dynamic random access memory), that has a storage cell composed of a condenser and a transistor, was an almost standardized mass manufactured device used personal computers. The specifications of DRAM had become almost standardized during 1980s. The mass production system of DRAM was established and Japanese companies occupied the top seventh places in world sales of the 1980s.

However, in the 1990s, their competitive advantage in the world market declined drastically.

It was said that Japanese companies were too late in entering the system LSI market. Mr. Okumura[4], a former engineer of Toshiba, and former visiting professor of Tokyo university, mentions that he predicted the development transition from DRAM to customized LSI would begin at the beginning of the 1980s. He says that demands for semiconductor technology customization should follow after from mass production standardization to agile production.

In 1990s monetary investment in R&D and semiconductor facilities was severe by Japanese semiconductor device makers and the development of investment conservative manufacturing machine was required in addition to the agile production system. Mr. Okumura considered that, to save monetary investment in manufacturing machine, it is necessary to shorten the manufacturing process work time to one third. To shorten the manufacturing process time, it is necessary to save time in the cleansing and verification stages which are located before and after the value added process. Then he created the concept of "Process Continuation" in relating to the manufacturing process.

Testing of the concept in application cost more than 6 million dollars and it was too risky in investment for one company. So Mr. Okumura suggested arranging a group of companies and a national project called the "Highly Agile Line Concept Advancement (HALCA)" was launched under the command of Professor Ohmi of Tohoku University.

At first, omitting cleansing process was taken into consideration to realize the concept. However, technological problems were too difficult to test for the whole concept of process continuity. To implement the project, the development concept was slightly changed from the process continuity to a concept of common use of machine system, where how to develop technology to realize through cleansing became critical, not to omit cleansing. This concept of common use of machine system implies a machine that can process three different kinds of films at the same time. To implement the test, the difference in capacity of each process machine, the difference among temperatures that are required to process films, differences among plasmagas for cleansing, and structure of chamber, etc., are all taken into consideration[5]. After all of the test, it was proven that a thermal machine that can process three different kinds of films decrease raw process time and dramatically, realizing 84 machines could be decreased to 40, and monetary investment savings of 60 to 90%, and so on. It is now being developed for use at 2 Toshiba factories in Japan.

To sum up, the process of developing concept of process continuation and making innovative machines based on the concept is as follows. First, observation of structural change of macroeconomics or premium users' needs is an important step to start with. In the case of the continuity line concept, an engineer of semiconductor processes predicted the future diversity of demand for users of semiconductor IC, observing the standardization of DRAM specifications at the time. Then the engineer decomposed of the DRAM process once he had completed it whereby he analyzed his process intellectual properties completely and developed the concept of the process continuation considering the changing macro economic

structural changes, shortage of money for investment, and diversifying needs of customers. To test his concept, he arranged a consortium consisting of device and machine manufactures, automobile and construction companies. The consortium became a center of collaboration where customers, machine makers, and clean room makers collaborated with each other. To concentrate members attention, process related variables such as work time, temperature, and so on, were visualized and process units were integrated into innovative minifabrication units and an investment conservative machine was produced. It can be said that, a series of process innovations generated product innovation in this case. New style Monodzukuri overcome the weakness that appeared in too complex system and long raw process time by concentrating on the concept of process continuation.

Generally speaking, Japanese people are good at collaboration between suppliers and customers, and in this case, among competitors. There were two competing machine manufacturers in the consortium, however an adjustment of interests was made by dividing the project into 10–15 working groups and implementation of the patent policy. In contrast, generally speaking, Japanese cultural weakness is the development of clear invention, patent, and intellectual property policy. However, the HALCA project overcame the general weakness of Japanese approach in innovation and invention. The head of R&D department of the HALCA project made a patent policy that coordinate the complex interests of competitors and customers. All the patents member companies had relating to the project were listed beforehand, and all the inventions member companies invented were recorded, packed in boxes, sealed and deposited at a warehouse in the presence of a notary public. The inventions generated in member companies after the project was over at the end of March 2004 were verified yearly from the view point of the relationship with the project.

Sometimes, it becomes a problem who invented process technology that control works of machine, that is embedded in machine. It seems that in HALCA project, such problem was not existed, though who invented semiconductor process is sometimes a problem when the process was invented through collaboration of a device maker and a machine maker. In this case, well designed patent policy worked. Further, unless shared vision or development concept were not penetrated among member researchers, it might difficult for competitors to cooperate each other.

Here Monodzukuri realizes where customers, suppliers, and also competitors invent new technologies based on scientific hypotheses in cooperation under a shared vision or the development concept of common use of machine system.

4. Service Development in Monodzukuri[6)]

In the semiconductor industry, minitualization, speed and value added elements such as customer benefits built in features are highly respected, and these elements are incorporated into products development and design by the industry. As Japanese design ability is limited in comparison with European countries and the US, trading companies that deal with design

assist software products are important.

Innotech, a trading company that deals with specifically with Electronic Design Automation, makes it one of major missions to give the best solution service to customers by arranging Ceidense's design assist products with other various kinds of products. In these days, design activities are divided into many modular units and integrated into a design flow. The design flow of semiconductor IC is as follows : customer specification - system design - function design - logic design - net list (a collection of data that express connection of circuit) - layout design. In such flow, allowance of time delay is very limited and it is impossible to absorb early stage errors at the later stage of flow, though such a practice was usual in the past.

Here, the differentiate approach is to 1) minimize errors and 2) designing in consideration with later stage elements at the early stage, or early stage elements at the later stage. As for the time delay, problems occur from the gap between the logic and layout. The gap influence on the quality of wiring. The problem depend also on size and function of IC.

Thus, customer needs towards design assist solution service become more and more complicated. To satisfy customers' needs, such abilities are required to understand customers' problem, and to make decision under a limited time and resources. In the design assist solution service, tangible products are not offered to customers. What they produce are intangible services that coordinate and intermediate among various EDA units and various users.

In addition, in order to shorten the development period, a certain level of standardization is formulated at the design. Making and using semi-customized design product unit called ASIC is one of solutions. ASIC is a cell unit with standardized logic units. In addition, design circuit cells with a certain function that is called semiconductor IP (SIP) are used in the world market. We regard modularity as reducing interdependency and complexity derived from integrality. However, SIP reuse is not so active in Japan comparing from foreign countries. Further, it is said that Japan is the only country that the reuse of SIP is not active.

The reason of the Japanese situation may be partly for the "Not Invented Here" problem, however the "Not Invented Here" problem is not the Japanese unique problem that is derived from cultural issues. The STARC (Semiconductor Technology Academic Research Center) mentions on its website as follows : the reuse of SIP may improve efficiency because they are ready made and standardized, however, companies spend much time, that is, more than 60 to 80% of the development time on verifying SIP that are not invented at the companies and this fact cause inefficiency.

In May 2000, IPTC[7], a SIP market intermediated by website, was established by the investment of Mitsubishi trading company, Toshiba, and Nikkei BP. In this market, a criteria of quality of SIP for users is clarified in order to promote the circulation, that is, 1) outline of SIP, 2) log and past history of SIP, 3) materials or documents that can be offered with SIP, 4) design style of SIP, 5) supporting service relating with SIP, 6) function verification, 7) logical integration, 8) related software.

One of merits of using SIP is originally that it can save development time including verifi-

cation. It is apparently contradiction that companies spend much time for verification of SIP. Then a hypothesis can be made that the stagnation of the circulating market is not derived from the function of SIP, but Japanese companies decision making criteria. The criteria of what is important to discuss may be different from that of foreign countries.

Considering that Japanese companies' original strength used to be in the closed and integral architecture of production system, it is not clear whether they should concentrate their efforts to become good at open and modular architecture. However, speed of development of semiconductor is one of important elements to be considered in the semiconductor industry. Saving time itself generates value of the company. The Japanese companies' attitude to make importance of quality is good, however, as for SIP, design unit, it is contradictory to spend too much time on verification where it was originally intended to save time of verification by standardization. It is important for each company to find out the appropriate balance between the efficiency and quality, standardization and customization.

People's spirit and culture are not easily changed by an individual company's effort. STARC, a research institute established in 2001 by private semiconductor companies, makes it one of their missions to promote standardization of design units. This mission includes promoting the reuse of SIP. It's role is considered to have an effect on getting companies attention on the value of decreasing complexity by incorporating modularity, that is, the standardization and reuse of SIP.

In 2006, spin-off of venture companies that are specialized for SIP can be observed in the market place. This movement implies that companies judged they could get increased revenue by selling SIP. It is difficult to conclude where the balancing point between modular and integral production system for Japanese companies, however spin-off of SIP companies shows a certain direction towards modularity of production system.

5. Revolution of the Traditional Monodzukuri Spirit in the New Style Monodzukuri

On the other hand, there is another stream of development. Now companies are developing in cooperation with each other the next-generation yubiquitous memory that has the collective characteristics of DRAM, flash memory and other kind of memories. One of the technological requirements for semiconductor development is minimization for the energy conservatism. However, a certain kind of IC gate film has to be made thinner for the minimization to be possible. It is predicted that the present film material cannot endure the increased current leak, and a new film material has to be developed based on nanotechnology to allow for minitualization. Nanotechnology is a general term for a technology that treats molecules on a nano-scale. At present, two new material development consortium projects are in progress : one is to develop new film material that can be used within 2 or 3 years and one is to develop new film material for the next generation of IC technology. In the IC technology, the latter project is aimed to challenge the physical limits of science.

In the latter project, Toshiba is deeply involved because it is active in developing the next generation yubiquitous memory called MRAM, that has the collective characteristics of DRAM, flash memory, and other kinds of memory. It is said that, in order to produce MRAM, the development of next generation material film is a crucial point. In this context, new style Monodzukuri is implemented in research efforts integrated to develop the science based technology.

Further, it is said that, for technology development based on nanotechnology, skill of controlling particles are in need. In this context, Monodzukuri skill can be interpreted to be an ultra-minute processing and Monodzukuri spirit be craftsmanship that cannot be expressed in document.

In addition, Monodzukuri spirit of creativity is crucial. This way of thinking is partly reflected the project Toshiba did for its celebration of 120 foundation. Toshiba implemented a project of reproducing Japanese style clock that the founder of Toshiba made more than 100 years ago. It is decorated by Japanese lacquer and many minute lines are drawn by a Japanese ink brush that is made of 26 bristles of armpits of rats living in a wooden made boat. The clock was reproduced by engineers of Toshiba and traditional craftsmen in Kyoto. Toshiba engineers said that, through the reproduction project, they reminded traditional Monodzukuri spirit once they lost.

As for traditional Monodzukuri spirit, it is said that Japanese craftsmen used to work with feeling and thankfulness to natural breath. Based on the historical fact, Tokiwa suggested the management style in which people learn successively from the natural observation. He calls its style “Chi” (knowledge, wisdom and mind) management learning from natural world.

It is astonishing that, to make the pottery, dried woods for baking, soil, fire and kiln are important. Craftsmen have to handle the natural material. To bake pottery, an important issue is how to control particles. It is coincidence that the controlling particles is a crucial factor also in nanotechnology. It is coincidences, however, considering that Toshiba try to show Monodzukuri spirit in nanotechnology, that is, development of material for film in the next generation, it might be possible to say that the new style Monodzukuri can be deepened by the revolution of traditional Monodzukuri spirit.

6. Implication

In this paper, I mentioned that the new style Monodzukuri and it’s two aspects : fusion of science, technology, and skills, supported by as sophisticated intellectual property policy and secondly, the concept and service development. I showed the development concept of process continuation and that, under the concept (a little modified), agile process suitable for producing value added flash memories was tested. I also pointed out the importance of solution service development by companies that deal with 3 D design assist units. It can be said that the inferior reuse of SIP may be derived from the Japanese cultural weakness, however,

nanotechnology science based development of next generation material require the strength of particle control, that is also a key issue for the traditional pottery creation.

In Monodzukuri, spiritual aspect is crucial. In traditional Monodzukuri, craftsmanship is highly respected, however, in the new style Monodzukuri, concept oriented attitude and creative spirit together with science based technology are added.

It is coincidence that one of the biggest Japanese semiconductor company try to show Monodzukuri spirit in nanotechnology, whose important issue is the same as baking pottery. However, it can be said that the most important issue for traditional and new style Monodzukuri is the attention to the inner world of individial. That would lead to a transnational multi-cultural efforts to collaborate each other in the next stage.

notes

1) The Ministry of Economy, Trade and Industries in Japan (METI) published "The National Strategic Vision of Monodzukuri" in 2005, whereas the current author is one of the committee members. In this vision, there is no definition of Monodzukuri, so that readers can interpret the word freely according to their "Monodzukuri" context.
2) Takanashi, T., "The new context of Cultural based Strategy : Transformation from Knowledge Management to Chi Management," The Knowledge Forum, held in Sao Paolo, Sept. 2006.
3) METI [2005] suggests that the current Monodzukuri should actively employ science based technologies, and that concept oriented attitude have to be appreciated.
4) As for HALCA project where Mr. Okumura was involved, see Okada, E. [June, 2006].
5) As for technological aspects of this project, see Mikata, Y. [2003].
6) See, Okada, E. [Aug. 2006].
7) IPTC was discontinned in 2007.

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